

## Research and Professional Briefs

## A New Portion Size Estimation Aid for Wedge-Shaped Foods

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## ABSTRACT

Dietary surveys are important for understanding food consumption patterns in national studies, clinical research, and patient counseling. Portion size estimation aids usually increase accuracy of consumers' reports of the amount of food they ate in dietary surveys. However, wedge-shaped foods (eg, pie, cake, and pizza) pose special problems; this shape is not easily estimated by previously available portion size estimation aids. In focus groups, respondents indicate they need a portion size estimation aid that is easier to use than a ruler for portion estimation of wedge-shaped foods. An adjustable wedge was developed and tested with 320 respondents, ages 18 to 65 years, of various races and education levels, and both sexes, in four states using multiple sizes and types of wedge-shaped foods. The accuracy of portion size estimation with the two portion size estimation aids was assessed. The adjustable wedge gave similar results to the ruler for most portions tested, but was more accurate ( $P < 0.05$ ) than the ruler in approximately one third of comparisons. Both aids resulted in substantial misestimation, indicating that regardless of aid some people have difficulty estimating portions of wedge-shaped foods. The adjustable wedge was easy for people to use and can be recommended as an option for estimating portion size of wedge-shaped foods.

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Accurate portion size estimation is essential to understanding dietary intake (1), particularly for energy-dense foods (2). Accurate estimation of portion sizes helps consumers control food intake and helps health professionals relate food intake with public health concerns (3-9).

Use of portion size estimation aids usually has resulted in more accurate estimation of portion size (10,11), although not always (12), and some research has suggested visual cues of portion size may influence intake (13). Many foods that are high in sugars, energy, and saturated fats (eg, pie, cake, and pizza) often are served in wedge-shaped portions, which may make estimation difficult for consumers. The need for developing novel portion size estimation aids has been noted (14-17) with suggestions that aids most similar to the shape of the food portions were best. Although research (14) indicates that rulers are easy to use for some foods, estimation of meat portions (3) shows a ruler produced more outliers than other portion size estimation aids and was chosen less than a portion size estimation aid more similar to the food shape.

In this article, data are presented on the adjustable wedge, a portion size estimation aid developed for use in dietary surveys, and results obtained with the adjustable wedge are compared with those of a traditional aid (ruler) for portion estimation of wedge-shaped servings.

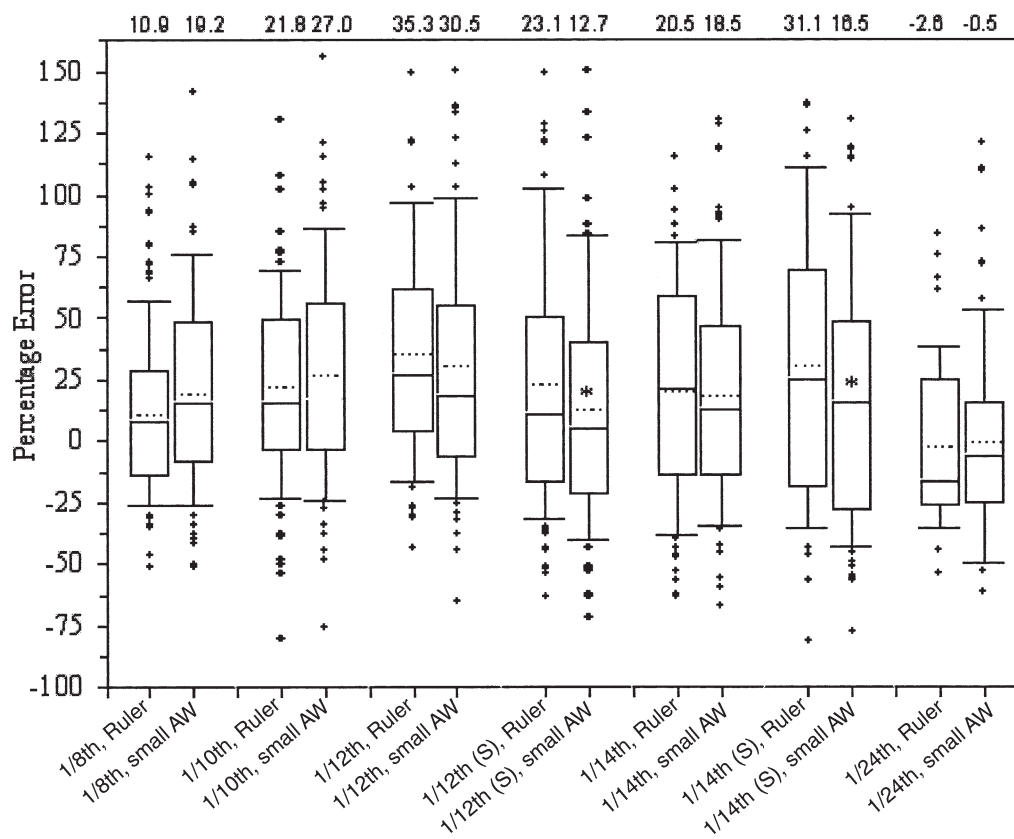
## METHODS

## Portions

Five portions of 9-inch cake were tested (Figure 1). All portion sizes were tested standing upright and two of the portions (1/12 and 1/14) also were tested lying on their side to examine potential perceptual differences for this popular placement of cake on a plate. Seven portions of pizza were tested (Figure 2). Pies were 9 or 10 inches (23 or 25 cm) in diameter, with seven total portions tested from 1/6 to 1/10 of a pie. Portions, assigned a random, three-digit numerical code, were kept out of sight until the participant was to estimate them.

## Subjects

A total of 320 subjects, aged 18 to 65 years, in California, Kansas, Ohio, and Tennessee (approximately 80 per state), estimated portion sizes using a ruler and the adjustable wedge. Subjects were recruited by telephone or in person from existing databases. During a 30-minute period, each subject individually evaluated three of the seven portions of each product category (ie, pie, cake, and pizza), based on a balanced incomplete block design. Sub-



### 23 cm Round Cake, PSEA

**Figure 1.** Mean, median, and distribution of percentage estimation errors for wedge-shaped cake samples evaluated with ruler and adjustable wedge (AW) portion size estimation aids (PSEA). Five portions of a 25-cm cake were tested; each portion was tested standing upright. In addition, two portions of cake (1/12 and 1/14) also were tested lying on their side and are marked with an (S). Numbers over the columns are the actual means, represented by a dotted line in the box. The median is represented by the solid line in the box. The lower and upper edges of the boxes represent the 25th and 75th percentiles, respectively, and the lines extending from the boxes represent the 10th and 90th percentiles. \*Means of the two portion size estimation aids are significantly different ( $P \leq 0.05$ ).

jects were paid an appropriate incentive. The research was approved by the Institutional Review Board on Human Subjects of the participating universities.

#### Portion Size Estimation Aids

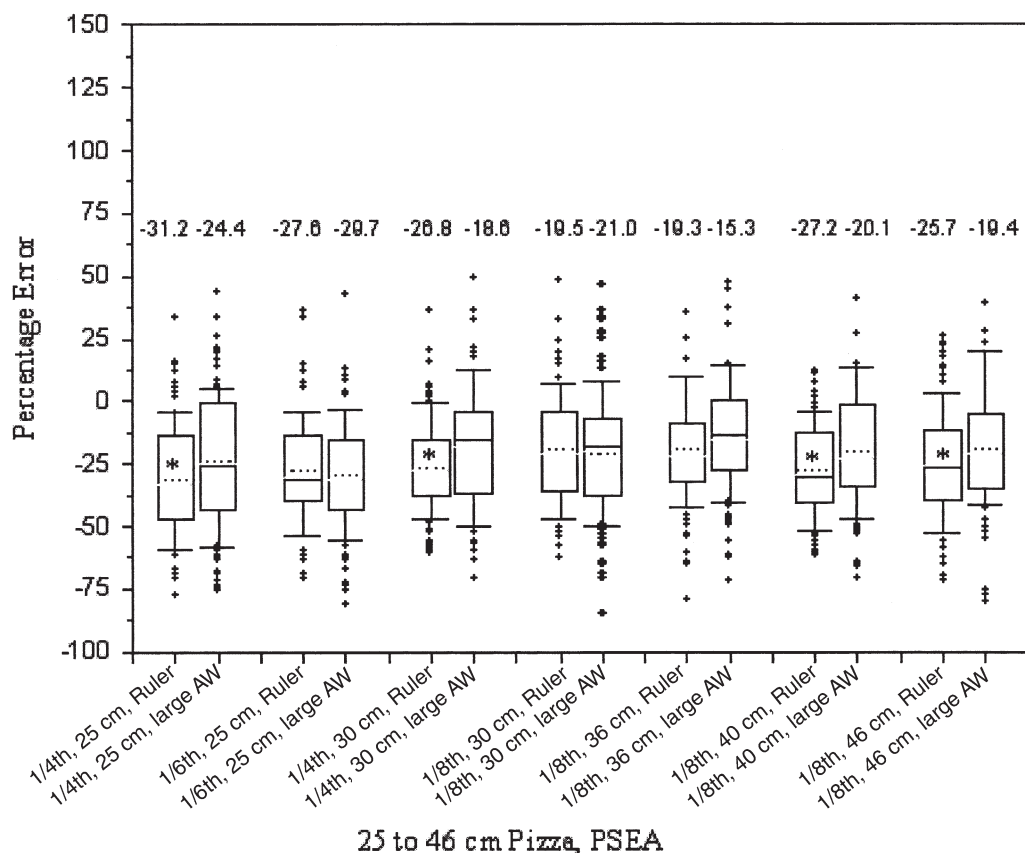
A 12-inch (30.5-cm) ruler and a 16-inch (40.6-cm) diameter (large; for pizza) and 10-inch (25.4-cm) diameter (small; for cake and pie) adjustable wedge were provided to subjects. The adjustable wedge was developed and pretested after subjects in focus groups requested an easier portion size estimation aid for estimating portions of wedge-shaped servings. This adjustable wedge was a full-circle precursor of the adjustable wedge (18) now used in the National Health and Nutrition Examination Survey (19). The adjustable wedge consists of concentric circles, one-half inch apart, labeled with a number representing inches (eg, 6.5 on the 6.5-inch diameter circle); the outside edge is labeled with letters 1-inch apart for estimating sample width. A moveable arm attaches to the adjustable wedge's center and extends to the outermost ring.

#### Estimation

First, subjects were shown how to use the portion size estimation aids. Then subjects viewed a portion for 30 seconds before it was removed. Portion size was estimated immediately thereafter because the aim of the study was to evaluate measurement accuracy, not recall. Subjects estimated portion size with the adjustable wedge by estimating length from the center tip to the outer edge, and width by rotating the arm of the adjustable wedge to the appropriate curvature point. The adjustable wedge was removed, and subjects estimated the portion's length and width using the ruler. Subjects were not allowed to modify their estimates after an aid was removed. Subjects were asked their confidence in the accuracy of their estimation immediately after using a portion size estimation aid. Confidence was measured using a scale from 1=extremely confident to 5=not at all confident.

#### Portion Estimation Calculation

A portion's length was defined as the distance from the center to outer edge, whereas width was defined as the



**Figure 2.** Mean, median, and distribution of percentage estimation errors for wedge-shaped pizza samples evaluated with ruler and adjustable wedge (AW) portion size estimation aids (PSEA). Seven portions of pizza wedges cut from 25- to 46-cm pizzas were tested. Numbers over the columns are the actual means, represented by a dotted line in the box. The median is represented by the solid line in the box. The lower and upper edges of the boxes represent the 25th and 75th percentiles, respectively, and the lines extending from the boxes represent the 10th and 90th percentiles. \*Means of the two portion size estimation aids are significantly different ( $P \leq 0.05$ ).

length of the curved edge opposite the portion's tip. The total area of the product ( $\pi \times \text{product radius}^2$ ) was calculated and the portion area was the fraction of that area (eg, one-eighth piece) multiplied by the total product area. The estimated size was calculated the same as the product, substituting the estimated length and width. Percentage estimation accuracies for length, width, and area, and subjects' confidence in the estimations were calculated.

#### Data Analysis

Comparisons of percentage misestimation for each food using the portion size estimation aids overall, by demographic subsets, and by respondent confidence estimates, were performed using analysis of variance with the SAS MIXED procedure (version 8.2, 2002, Statistical Analysis System for Windows, Cary, NC).  $P \leq 0.05$  was chosen to define statistically significant differences.

Outliers were defined as data outside three standard deviations of the mean; they were not included in the analyses. This eliminated 4.6% of observations (262 of 5,760 observations). Outliers usually were overestimation of width and were not related to the specific portion

size estimation aid, nor the subject's age or sex. Almost one third of outliers were for width measurements of the 1/24th slice of cake, where approximately 40% of respondents overestimated by more than 100% (three standard deviations).

#### RESULTS AND DISCUSSION

The population in this study was 59.9% women, 40.1% men; 51% white non-Hispanic, 32% African American non-Hispanic, 8% Hispanic, 2.5% Asian, and 6.5% "other." Approximately 12% of subjects had a high school diploma or less education, 46% attended college or trade school, and 42% completed college. Because, similar to previous research (3), respondents' age, education, race, ethnicity, and sex did not significantly affect accuracy of estimations, only overall data are reported. Misestimations of the total area of cake and pizza are plotted in Figures 1 and 2. The amount of pizza typically was underestimated about 20% on average and cake was overestimated about 20% on average. For pizza, four of seven portions were significantly better estimated by the adjustable wedge. For cake, two portions were better estimated by the adjustable wedge. Interestingly, the cake

samples that showed differences were shown lying on their side. Regardless of the differences, the dispersion of estimation errors shown in the plots indicates that the number of individual misestimations of more than 25% (both over- and underestimations) was substantial for both tools.

Data for pie are not shown, but had similar underestimations and dispersion of data as for pizza. The only significant difference for pie was a better estimation of the 1/10 piece of the 9-inch (23-cm) pie for the ruler ( $-12.5\%$ ) vs the adjustable wedge ( $19.5\%$ ). Misestimation typically was greater for width than length. All mean misestimations for length were less than 12% and most (20 of 38) were less than 5%. Only two of the mean width misestimations were less than 5% and most (28 of 38) were more than 15%.

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## **The large number of misestimations with both portion size estimation aids suggests that wedge-shaped food portions are difficult for individuals to estimate.**

Subjects were more confident ( $P < 0.05$ ) in their portion estimates when they used the adjustable wedge than they were when they used the ruler. However, as in other research (11,15,16), confidence did not equate to accuracy. Respondent comments indicated they preferred to use the adjustable wedge and that it was more intuitive and less intimidating than the ruler. Previous research (3) showed that people preferred other portion size estimation aids to the ruler. Unfortunately, portion size estimation aid preference was not formally measured in this study.

Foods with a lower profile (low height or less thick), such as pizza and pie, appear to be underestimated by consumers, whereas a thick product (cake) generally was overestimated. With cake, product orientation (lying on its side) influenced subjects' ability to use the ruler effectively; the adjustable wedge gave significantly lower misestimations than the ruler.

A limitation of the study is that individuals only looked at foods and did not eat them and have to recall the portion later. However, this study was designed to compare estimation accuracy using specific portion size estimation aids, a primarily visual perceptual task, not recall accuracy, which is a more complex cognitive task. Validation studies using actual consumed foods and recall methods ultimately are needed. A second limitation of the study is that the adjustable wedge always preceded estimation with the ruler. Thus, some subjects could have gained knowledge using the adjustable wedge that would help them with the ruler. However, if that occurred, then actual ruler estimates would be worse than those found. Thus, the conclusions and recommendations do not change.

### **CONCLUSIONS**

The large number of misestimations with both portion size estimation aids suggests that wedge-shaped food portions are difficult for individuals to estimate. No signifi-

cant difference was found for most portions tested, especially smaller sized portions such as pie and cake. The adjustable wedge estimation aid does appear to reduce average population estimation error for some larger portions of wedge-shaped foods (eg, pizza).

The wedge appeared to be easy to use and gave respondents more confidence in their estimates. However, confidence did not equate to more accurate estimation. Because subjects were less intimidated when using the adjustable wedge, ruler-challenged clients may find the adjustable wedge a helpful tool.

The adjustable wedge portion size estimation aid provides an easier method of dietary assessment for wedge-shaped foods and is at least as accurate as, if not more accurate than, a ruler, which is commonly used for wedge-shaped foods.

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